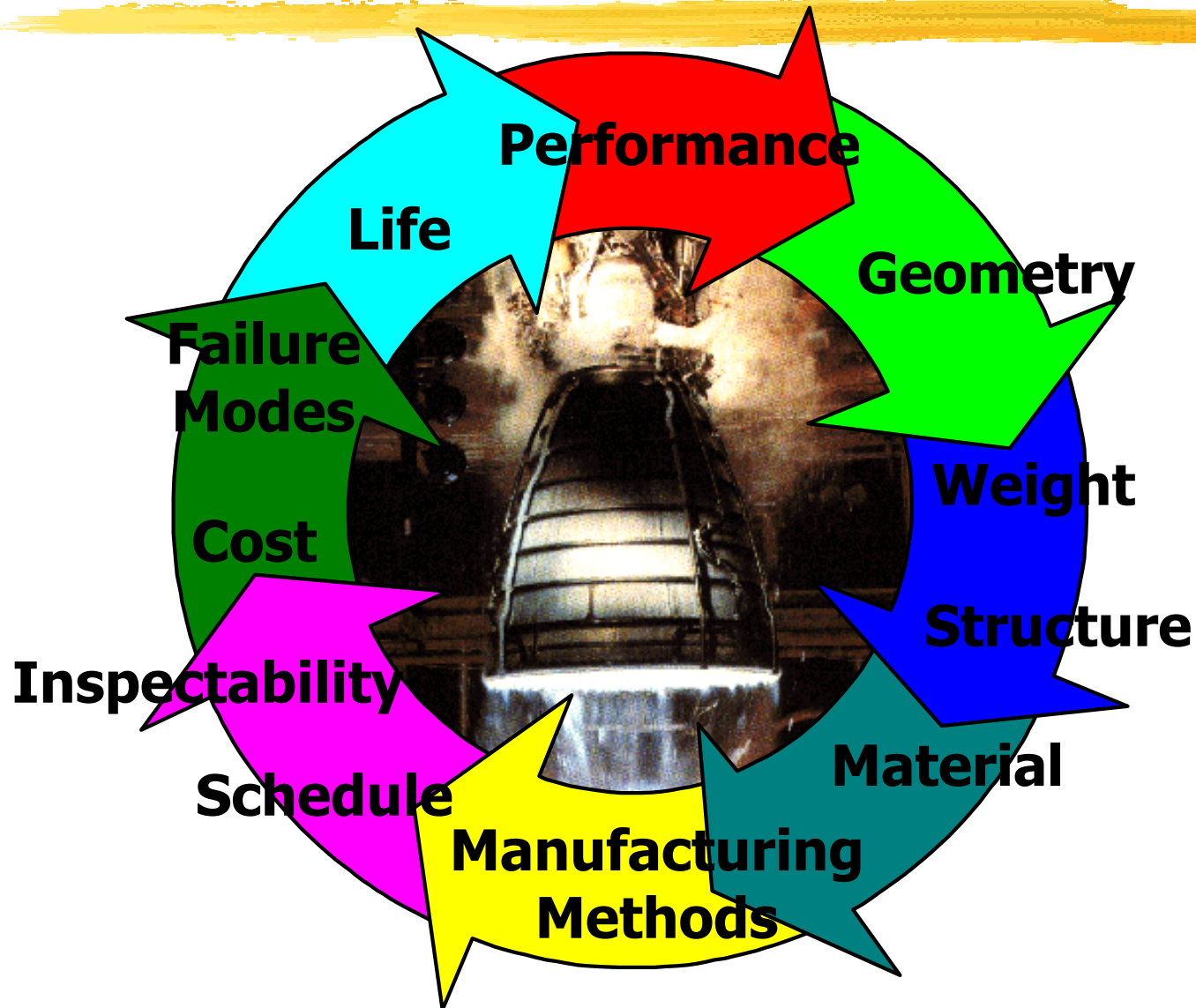




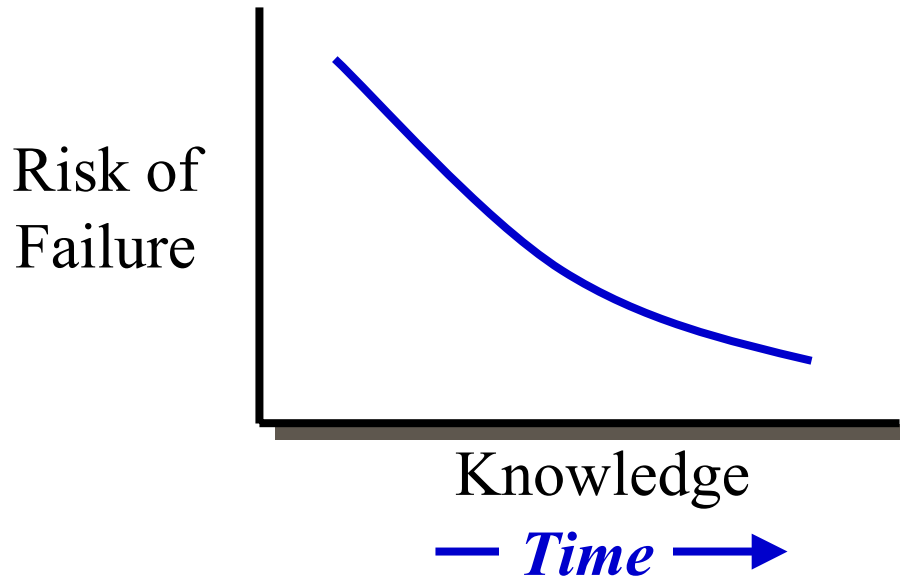
Decision Management: A New Design Paradigm being pursued at Boeing

**Jeff Fint, and Joe Onstott, Boeing, Space and
Communications Division
Dr. David G. Ullman, Robust Decisions Inc.**

The Endless Cycle of Trades



Design Risk vs. Knowledge



- The challenge for a good design is to have the required knowledge at the time the design decision is needed
- The catch - time, resources and the market

Trade Studies and Decision Making

- **Must select one alternative in an uncertain environment.**
 - Unrefined information: *some even qualitative*
 - Conflicting information: *evaluation and importance varies across team members*
 - Evolving information: *the problem is changing with time*
 - Incomplete information: *evaluation is incomplete*

Traditional Trade Study Approach



■ Modified Pugh Tool

- Identify trade parameters
- Assign weight to individual criteria
 - Total weight equal to 100%
- Rate criteria against design concept
 - Use scale 1-10 in matrix form
- Multiply weight and rating
- Add total scores and compare

Traditional Trade Study Approach

Modified Pugh Tool

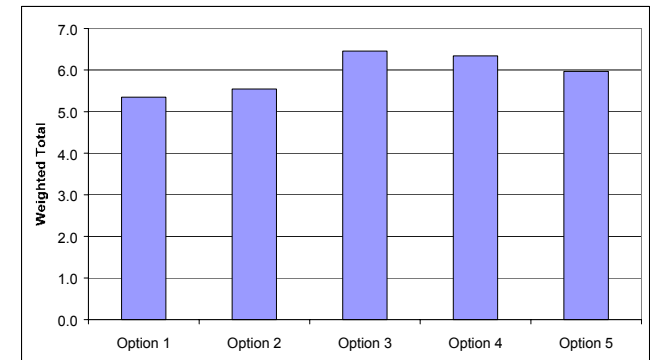
Weights

Category

Safety - 50%

Criteria	Weight	Option 1	Option 2	Option 3	Option 4	Option 5
Inspectability	15%	5.0	5.0	6.4	6.4	3.6
Process Variability	40%	3.0	4.4	4.7	4.7	3.3
Hardware Robustness	25%	3.5	4.7	5.8	5.6	4.3
Failure Mode Count	15%	5.6	5.6	6.3	6.3	5.0
Materials	5%	5.0	5.0	5.0	5.0	5.0
Weighted Total	50%	3.3	3.7	4.2	4.2	3.2
Cost	60%	4.0	4.0	5.4	5.2	4.6
Schedule	20%	5.0	5.0	5.0	5.0	4.0
Risk	20%	4.3	4.3	5.6	5.6	6.9
Weighted Total	40%	8.0	8.0	9.6	9.5	9.3
Performance	50%	4.0	4.0	4.0	4.0	6.0
Turn Around	50%	6.0	6.0	6.0	5.0	7.0
Weighted Total	10%	5.0	5.0	5.0	4.5	6.5
Weighted Total	100%	5.3	5.5	6.5	6.3	6.0

Final Comparison



Pugh Matrix

Issues With Traditional Approach



- **Assumes all alternatives have the same level of knowledge for each criteria**
 - Strong voices dominate
 - Ignorance is bliss - uncertainty often not dealt with
- **Assumes all experts have same experience base for the options**
- **Hard to achieve consensus**
- **Difficult to determine best option when final comparison is close**

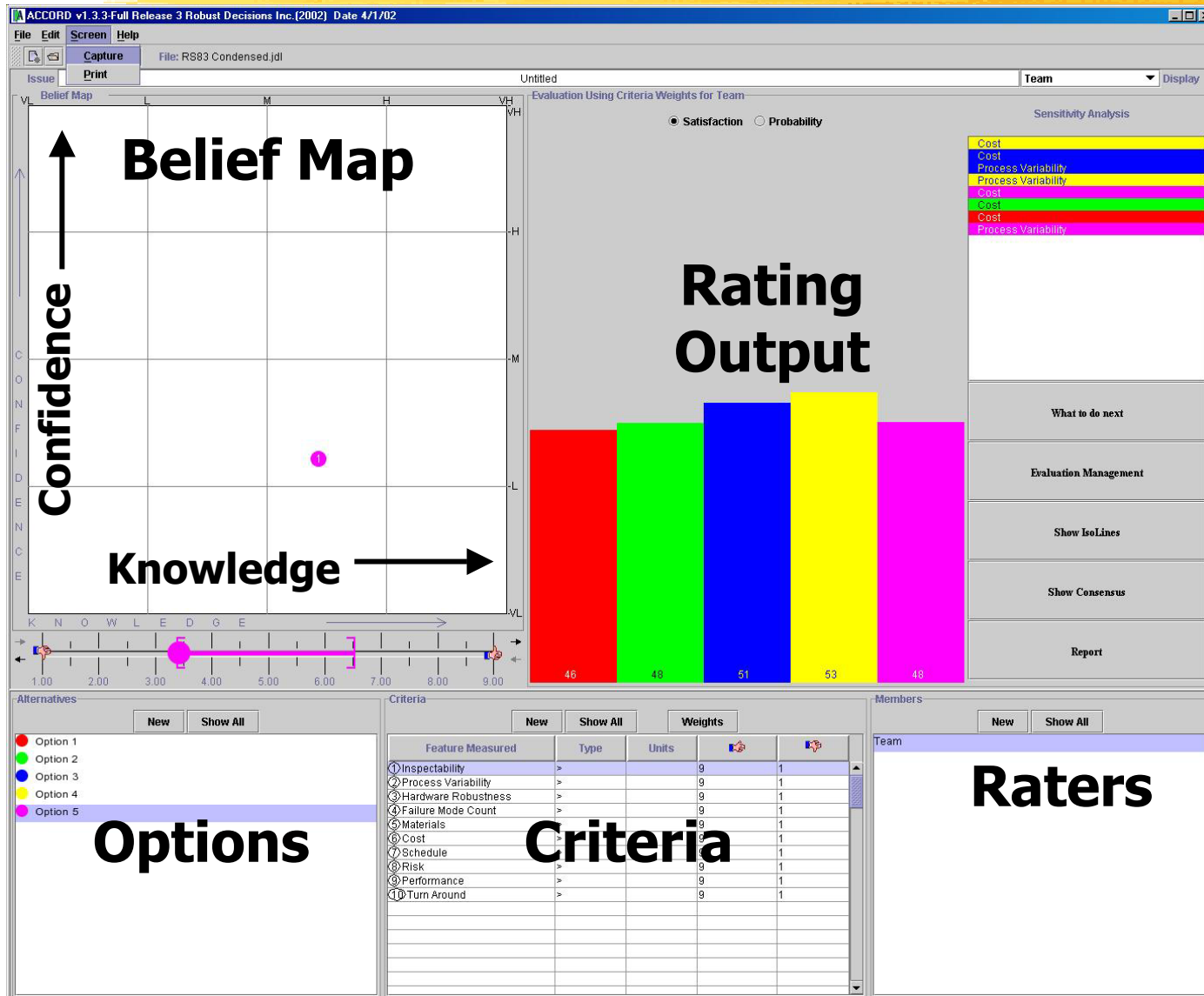
New Trade Study Approach

The *Accord*™ Tool



- ***Accord*™ developed by Robust Decision Inc. (www.robustdecisions.com)**
- **Supports decision management of teams with uncertain information**
- **Allows for independent expert opinions**
- **Allows experts to use independent weightings**
- **Supports Robust Decision Making - Choosing the best alternative with the least sensitivity to uncertainty.**

Accord Features



Functions

***Accord* analysis methodology**

- ***Accord* is based on Bayesian decision theory extended to support multiple decision-makers**
 - Allows uncertainty to be a major factor in the analysis
 - Allows multiple preference models
 - Allows simple model of team members' beliefs
- **The analysis includes**
 - Subjective expected utility
 - Marginal Value of Information
 - Probability of being best
 - Risk (new feature in next revision)

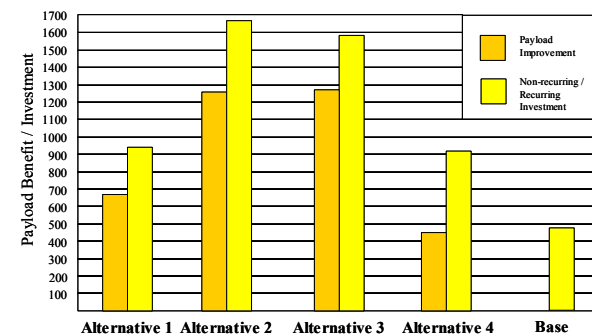
Rocket Nozzle Case Study

New designs compared to current

- Using *Accord* - Results reached with-in a few hours with multiple strong personalities
 - Mixture of quantitative and qualitative data
- Using traditional approach - Similar results achieved in one month
 - Additional time used to quantify criteria



V.S.



Component Case Study

New Approach with Accord

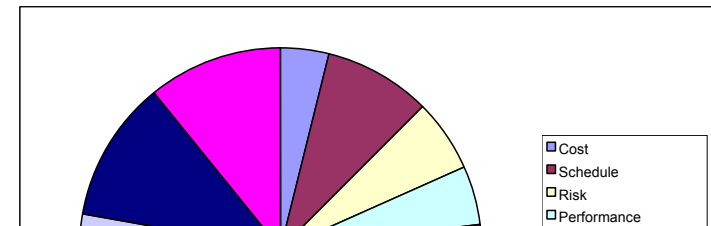
Pair-wise comparison approach for criteria weight development

Typical 10 alternative pairwise comparison

Criteria	Weight
1 Cost	2
2 Schedule	2
3 Risk	2
4 Performance	2
5 Turn Around	2
6 Inspectability	2
7 Process Variability	2
8 Hardware Robustness	2
9 Failure Mode Count	2
10 Materials	2

Importance						
Much	More	Equal	Less	Much		
Cost	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	Schedule	2
Cost	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	Risk	2
Cost	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	Performance	2
Cost	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	Turn Around	2
Cost	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	Inspectability	2
Cost	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	Process Variability	2
Cost	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	Hardware Robustness	2
Cost	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	Failure Mode Count	2
Cost	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	Materials	2

	Cost	Schedule	Risk	Performance	Turn Around	Inspectability	Process Variability	Hardware Robustness	Failure Mode Count	Materials
Cost	1.00	4.00	2.00	2.00	2.00	4.00	4.00	2.00	2.00	2.00
Schedule	0.25	1.00	0.50	0.50	1.00	2.00	2.00	1.00	2.00	2.00
Risk	0.50	2.00	1.00	0.50	1.00	4.00	4.00	1.00	4.00	2.00
Performance	0.50	2.00	2.00	1.00	2.00	4.00	4.00	1.00	4.00	2.00
Turn Around	0.50	1.00	1.00	0.50	1.00	2.00	2.00	0.50	2.00	2.00
Inspectability	0.25	0.50	0.25	0.25	0.50	1.00	1.00	0.25	0.25	0.50
Process Variability	0.25	0.50	0.25	0.25	0.50	1.00	1.00	0.50	0.10	0.50
Hardware Robustness	0.50	1.00	1.00	1.00	2.00	4.00	2.00	1.00	2.00	2.00
Failure Mode Count	0.50	0.50	0.25	0.25	0.50	4.00	2.00	0.50	1.00	0.50
Materials	0.50	0.50	0.50	0.50	0.50	2.00	2.00	0.50	2.00	1.00
Sum	4.75	13.00	8.75	6.75	11.00	28.00	24.00	8.25	19.35	14.50
Product vector	0.4	1.0	0.7	0.5	0.9	2.5	2.1	0.7	1.3	1.2
	4%	9%	6%	5%	8%	22%	19%	6%	11%	11%



Accord used with multiple data sets

- Data set's e-mailed to experts - options rated and recombined

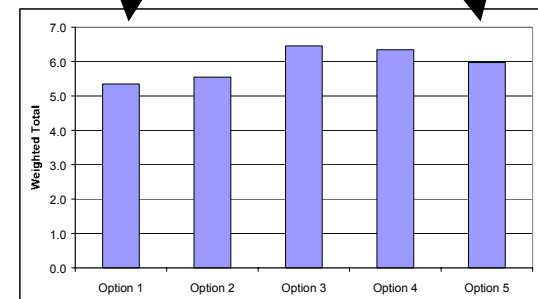
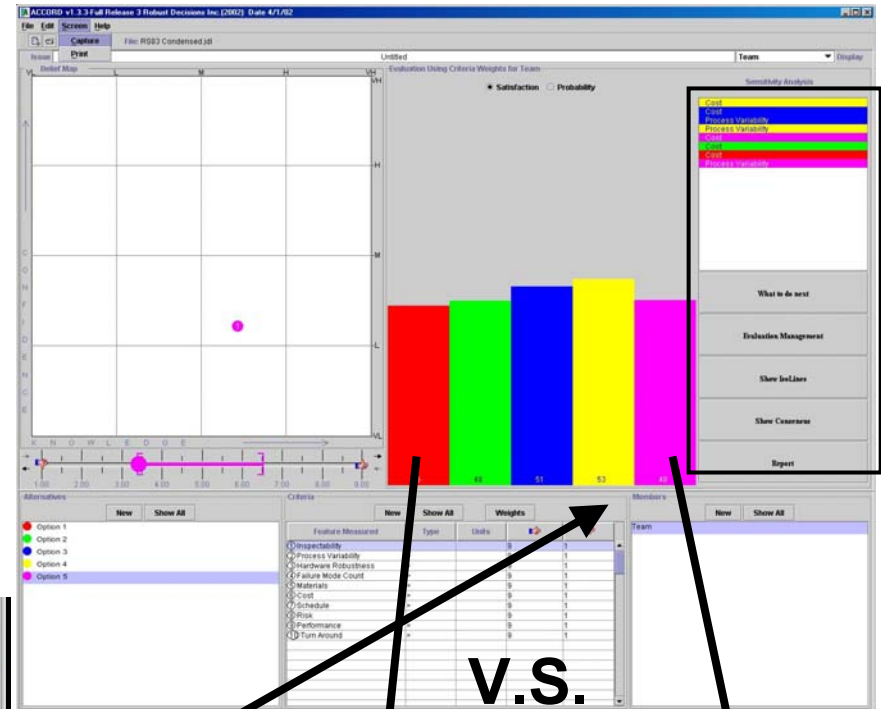
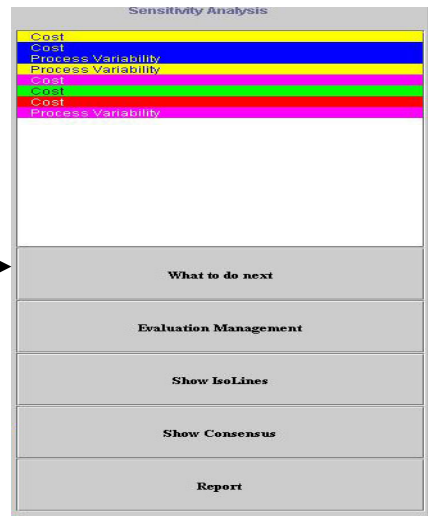
Component Case Study

New Approach with *Accord* - Results

- Results consistent with Pugh approach
 - Uncertainty discriminator for close options
- Accord results provide suggestions for next steps

Decision Drivers →

What to do Next →



Additional *Accord* Functionality



- ***Sensitivity Analysis*** (Value of information) relates the value of more work on a specific evaluation
- ***Consensus*** shows how well the team agrees in its evaluation.
- ***Evaluation Management*** allows the inclusion of evaluation information from selected team members

Advantages For Design Decisions

- **Ability to manage uncertainty of knowledge**
 - Increases confidence in decisions
 - Helps target areas for risk mitigation
- **Significant potential time saving due to lowering the risk of repeating a design cycle in the development process.**
- **Ability to manage strong personalities**
- **Facilitates team consensus**
 - Allows productive discussion of different views